III. — NOTES ON THE FAUNAL SUCCESSION IN THE CARBONIFEROUS LIMESTONE OF WESTMORELAND AND NEIGHBOURING PORTIONS OF LANCASHIRE AND YORKSHIRE.

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IN August last, at the meeting of the British Association at York, I gave a general account of the zonal succession of the Carboniferous Limestone as developed in Westmoreland and North Lancashire, and I instituted a comparison with beds of a similar age in the Ingleborough and North Pennine districts.

In response to a request made at the meeting, I drew up a table in which a provisional correlation was attempted with the zones of the Avonian Succession. I had not then, however, had the opportunity of consulting Dr. Vaughan regarding his most recent conclusion, the correlation with the Avonian Succession being based on the tables accompanying his paper and that of Mr. Sibley on the Mendip area.

I hope shortly to describe the Northern Succession more fully, but meanwhile I take the opportunity afforded by the courtesy of the Editor of the GEOLOGICAL MAGAZINE to bring forward the problems involved in any correlation of the northern areas more fully than could be done in the short abstract published by the Association, and to revise the attempted correlation of the lower beds with Dr. Vaughan's zones.

The key to the northern area lies in the *Michelinea megastoma* bed as developed in the Arnside section, where it contains a rich fauna. This bed, together with the underlying Meathop Limestones, I have long considered to lie near the base of the succession in the north, but its relation to the Shap and Ravenstonedale Limestones and the overlying Ashfell Beds was not absolutely clear, on account of the absence of the *Michelinea* bed from the eastern exposures. The lowest bed at Arnside contains amongst others the following characteristic forms:—

Michelinea megastoma.
Zaphrentis aff. *cornucopiæ.*
Caninia cylindrica.
Productus aff. *punctatus.*
Orthotetes crenistria.
Athyris expansa.
Chonetes cf. *comoides.*

In addition a very characteristic *Cyathophyllum* occurs in which the septa show a marked Zaphrentid type of grouping, and a new species of *Clisiophyllum*, which Dr. Vaughan has since told me he is about to describe from the basement bed at Horton, where it also occurs.

Dr. Vaughan agrees with me that this fauna points to a position near the top of his C zone in the Bristol area. No Lithostrotions occur in the *Chonetes* bed, but immediately above, in the overlying Black Limestone of Blackstone Point, they occur in abundance, together with *Diphyphyllum* and Campophyllids, and I therefore take the Blackstone Point Beds as representing the base of S_1.

These beds can be traced for a mile or two in an easterly direction, and reappear again near the base of the Scout Scar section, both in the Brigsteer and Underbarrow road cuttings (Barrowfield Beds of the table).

In the Brigsteer section occur all the species characteristic of the Arnside Beds, including the giant *Chonetes* cf. *comoides* and unusually large specimens of *Orthotetes crenistria*, neither of which occurs above this horizon in any section I have examined in the north. Indeed, the greater part of the fauna of the bed is strictly limited to this horizon, and nearly the same association occurs at the base of the Ingleborough succession,[1] and undoubtedly represents the same horizon.

Any beds, therefore, below these are of special interest, as they carry us well down into C or lower. Such beds occur at Low Meathop, opposite Arnside, and at Crag Mollet in the Brigsteer section; in both places they consist of purple dolomitic limestone, and contain fine silicified specimens of *Syringopora* (cf. *reticulata*) and small Cyathophyllids and Seminulas, while at the base at Crag Mollet occurs a bed marked by clusters of *Diphyphyllum pseudo-vermiculare* (McCoy).

If this Diphyphyllid *Lithostrotion* is to be considered typical of (S), then the whole of the Arnside Beds and the Horton Beds will have to be included in (S) also. It is possible, however, that we have here the forerunner of the *Lithostrotion* fauna, which becomes so characteristic of the *Seminula* zone above.

In the Shap and Ravenstonedale district further east the *megastoma* bed is absent, but the same purple dolomitized limestones with *Syringopora* occur towards the base, though they are here much thicker and include lower beds than any found at Kendal or Meathop, so that at Ravenstonedale we probably have the lowest beds found anywhere in the district. The absence of the *megastoma* bed makes the sequence rather more difficult to subdivide, but as the result of many years' work in the district I have come to the conclusion that this bed is represented in the Shap area by the sandstone near the base of the Ashfell series.

The evidence on which I rely is as follows:—At Brigsteer, immediately beneath the *Michelinea* bed, we have the Crag Mollet Bed full of *Diphyphyllum pseudo-vermiculare*, which, as far as I am aware, has not been found elsewhere at any higher horizon. The same form occurs abundantly near the top of the Shap-Ravenstonedale Limestone near the base of the Ashfell group, so that the latter should include the *megastoma* bed.

Again, the base of the Knipe Scar or Melmerby Limestone, resting on the Ashfell Beds, is crowded with silicified specimens of *Cyrtina carbonaria*, a form characteristic in the western area of the base of the upper *Seminula* zone[2]; furthermore, in the Shap section at the base of the Ashfell series, occurs a thin layer enclosing remains of *Camarophoria isorhyncha*, a form characteristic of the very base of the lower *Seminula* zone.[3]

Lastly, at Kettlewall, on the east side of the Kendal outlier, we have an epitome of the sequence in both areas. Here the *megastoma* bed, very much reduced in thickness, is overlain a few feet above by a limestone containing *Cyrtina carbonaria* (the locality whence the type-specimens figured by McCoy and Davidson were obtained), and it has already been shown that the bed containing *Diphyphyllum pseudo-vermiculare* underlies the *megastoma* bed on the west side of this outlier. It seems, therefore, practically certain that the Ashfell Sandstone, with its included limestones, represents the whole of the lower *Seminula* zone, and that the *megastoma* bed is represented by the very top of the Shap-Ravenstonedale limestone or the base of the Ashfell group.

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[1] See Cosmo Johns & Vaughan: Geol. Mag., 1906.

[2] Dr. Vaughan: Q.J.G.S., vol. lxi, p. 254, footnote.

[3] T. F. Sibley: op. cit., vol. lxii, p. 376.

This fact is of great interest outside the question of local correlation of these northern exposures, as it shows that in the northern area we have a marked upheaval producing shallow-water conditions at the top of the Tournasian and base of the Viséan times, similar to that recorded from the south-west province, the Ingleborough district, and elsewhere, resulting possibly even in contemporaneous erosion in some places.

With regard to the age of the lowest beds at Shap Abbey and Ravenstonedale, it is difficult to speak with certainty here. I was at first inclined to place the lowest beds at Ravenstonedale as low as Dr. Vaughan's *Cleistopora* zone, on account of the occurrence of a flat encrusting coral resembling *Cleistopora*, but Dr. Vaughan informs me this is not his typical form, and as this may not be a *Cleistopora* I have taken *Athyris glabristria* and *Spirifer* aff. *clathratus* [1] as characteristic forms for these lower beds. The latter occurs throughout the lowest beds,[2] but is specially abundant at the base, the former being plentiful near the bottom of the Shap-Ravenstonedale Limestone, while this limestone, as stated above, is everywhere characterized by a fine *Syringopora*. As *Spirifer* aff. *clathratus* occurs throughout Z and K in the Bristol area, and as corals also occur, which, though badly preserved, appear to resemble *Zaphrentis Phillipsii*, I have provisionally assigned the lowest beds in the Ravenstonedale district to the *Zaphrentis* zone of the Avon district.

The Shap Abbey Beds do not appear to include these lowest beds, and although they are rich in *Athyris glabristria* and also contain a species of *Spiriferina* and Modioliform lamellibranchs, they will probably not be found to represent beds much below the base of the C zone of Dr. Vaughan.

The correlation of the higher beds in the table does not call for much comment here. The presence of *Lonsdaleia floriformis* and *Petalaxis Portlocki* at Humphrey Head together with *Dibunophyllum* aff. ψ at Grange, shows, that the upper *Dibunophyllum* beds are represented in the western extension of the district, and that a fault occupies the Kent estuary, bringing the lowest beds at Meathop against the highest beds at Grange. The same association of forms at Outscar, Bampton, and elsewhere, shows, that these upper beds are also present in the Shap district, and the beds below contain a typical lower *Dibunophyllum* fauna with *Cyathophyllum Murchisoni* and *Alveolites septosus* and characteristic *Producti*.

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[1] Kindly determined for me by Dr. Vaughan.

[2] Lower Limestone Shales of the Government Map.

Dr. Vaughan's Zones.	SUB-ZONES SUGGESTED FOR WESTMORELAND AND WEST YORKSHIRE.	SHAP DISTRICT.	RAVENSTONE-DALE.	ARNSIDE GRANGE DISTRICT.	KENDAL.	NORTHERN PENNINES.	INGLEBOROUGH AND PENYGENT.
D_3	*Productus* cf. *Edelburgense.*	...	...	...	...	...	Upper Scar Limestone.
D_2	*Dibunophyllum* in stage ψ. *Productus latissimus.*	...	...	Kent's Channel Beds.	...	Great limestone, Teesdale and Weardale.	Limestone of Hull Pot Gill.
	Productus giganteus. *Lonsdaleia floriformis.*	Outscar Beds. Bampton, etc.	(?)	Humphrey Head, east side. *Petalaxis Portlocki.* *Cyathophyll. regium.*	(?)	*P. giganteus* beds. 'Scar limestone.' *Lonsdaleia* bed. Hilton Beck. Hardraw Scar, etc., etc.	Hunt Pot Beds, with *Dibunophyllum* aff. ψ. *Spiriferina* cf. *octoplicata.*
D_1	*Dibunophyllum* in stage θ. *Cyathophyllum Murchisoni.*	Upper Knipe Scar. Up. Hardendale Nab. Upper Orton Scar.	(?)	Humphrey Head, west side. Eggerslack Beds.	Serpentine Walks Limestone.	Upper Melmerby Limestone of Middle Tongue Crag, etc.	Upper Ingleton (White Scars) Beds. *Dibunophyllum* aff. θ.
S_2	*Productus corrugato-hemisphericus.* *Chonetes papilionaceus.*	Lower Hardendale Beds.	? Waitby Beds.	Arnside Knott and Wharton Crag.	Upper Scout Scar Beds.	Lower Melmerby Limestone. Long Fell. Musgrave Scar, etc.	*Chonetes papilionaceus* beds, White Scars, Moughton & Horton Sc.
	Nematophyllum minus. *Cyrtina carbonaria.*	? Ashfell Sandstone.	Smardale Fell. *Cyrtina* beds. Upper Ashfell Sandstone.	Hampfield Beds. Lower Wharton Scar. Far Arnside, Middlebarrow, and Sandside Quarries.	Lower Scout Scar Beds. Kendal Fell. Kettlewell Quar. *Cyrtina* bed.	? Bituminous limestone beds of Roman Fell.	*Bellerophon* beds of Horton, Coombe and Craven Quarries, with *Nematophyllum minus.*
S_1 C_2	*Michelinea megastoma.* *Caninia cylindrica.* *Chonetes* cf. *comoides.*	? Water's Farm Series. *Camarophoria isorhyncha* bed. ? Docker Beek Oolites. ? Gastropod bed.	? Lower Ashfell Beds. ? Upper Ravenstonedale Limestone.	Blackstone Pt. Beds. Arnside Beds, with *Z. cornucopiæ* and *Chonetes* cf. *comoides.*	Barrowfield Beds Kettlewell Cave Beds.	Roman Fell Sandstones, with *Syringothyris* cf. *cuspidata.*	? *Paludina* shale, Horton in Ribblesdale basement bed, Ingletondale, etc., with *Michelinea* and *Caninia.*
? C_1	*Syringopora* cf. *reticulata.* *Diphyphyllum pseudo-vermiculare.* *Productus* cf. *burlingtonensis.*	*Diphyphyllum* bed. Raisbeck, etc. *Spiriferina* shale. Bryozoa bed.	Middle Ravenstonedale Limestone.	Meathop Fell Beds.	*Cyathophyllum* cf. *Murchisoni* bed. Crag Mollet *Diphyph'm* bed.		
? Z	*Athyris glabristria.* *Spirifer clathratus.*	Basement conglomerate.	Stone Gill Beds. Basement beds Pinskey Gill, etc.				

A (?) placed before a bed implies that the index fossil has not been found in it.

In the Horton district we appear to have a normal succession. On Ingleborough, above the *Caninia* basement bed S_2 is represented by the *Bellerophon* bed with *Nematophyllum minus*, and is in all respects similar to the same zone on Scout Scar, Hampsfield Fell, etc. Above these, beds rich in *Chonetes papilionaceus*, *Lithostrotion Portlocki*, and *Alveolites septosa* succeed, and corals allied to *Dibunophyllum* ϕ are not uncommon still higher with characteristic *Producti*. But I do not know of the occurrence of *Lonsdaleia floriformis* or *Productus giganteus* on Ingleborough. On Penygent, however, at Hunt Pot, we have a rich fauna of upper *Dibunophyllum* age containing, beside the typical *Productus giganteus*, *Lonsdaleia floriformis*, *Dibunophyllum* aff. ψ, *Lithostrotion junceum*, etc. In the lower shale band a *Spiriferina* closely related to *octoplicata* is common, and Dr. Vaughan tells me that he has lately traced Sowerby's type-specimen of *Spiriferina octoplicata* to an horizon which appears to be D_2, the identical horizon of the Hunt Pot Beds.

The bed above this on Penygent is frequently crowded with *Productus latissimus* and thick reefs of *Dibunophyllum* in the ψ stage, a form which appears to be larger and longer than the typical examples. This bed is represented on Ingleborough by the cement-stone bed seen in the swallowhole dedicated in the Ordnance map to Tatham's wife, and is also found at Riblehead. The same zone occurs in the Wensley Dale district at the top of the Hardraw Scar Limestone, while the bottom of that bed is full of typical *Productus giganteus*.

The highest zone in the district, that contained in the Upper Scar Limestone, shows a further modification of the giant *Producti* to a form which, some years ago, I tentatively referred to the variety *Edelburgense*.[1]

IV.—The Rocks of Northern Guernsey.

By John Parkinson.

Introduction.

In a communication to the Geological Society in 1900 I had occasion to compare the rocks of the south-eastern coast of Jersey with the hornblende gabbro, diorites, and granites of Northern Guernsey; and to point out that in general terms the petrographical types of the two islands bore a close resemblance to each other, group for group, in sequence and general relations. Since work abroad renders it improbable that I shall be able to devote much additional time to this subject, the following notes are given as a possible aid to future observers.

The very valuable work of the Rev. Edwin Hill[2] in this island renders superfluous any lengthy note on general characters; suffice it to say that the southern part of the island consists of gneiss with a few intrusive masses and dykes; the northern of diorites and intrusive granites, except for an oblong area on the eastern coast,

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[1] I here limit the term *giganteus* to the large coarse-ribbed forms found, as far as I am aware, only in the *Dibunophyllum* zone, and usually confined to the upper part of that zone.

[2] Quart. Journ. Geol. Soc., vol. xl (1884), p. 404 and map.